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Formation of engineering thinking at school during the lesson-game "solar system"

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Abstract

This paper describes the structure, conduct, and the main stages of the interdisciplinary lesson-game. Some data on the principles of educational technology are given. Methodical recommendations for conducting the lesson, as well as examples of didactic tasks are given. The proposed lesson carries the task - to build a model of the solar system. But this is not a simple design and construction but a deep didactic analysis. The results will be the construction of a model of the solar system, as a result of the application of engineering thinking skills in life, as well as the transfer of the project modeling algorithm from theory to practice.

Keywords: Physics, engineering thinking, interdisciplinary, divergent thinking;

1. Introduction

In the modern world, students have a low motivation for learning. This applies to both humanitarian subjects and scientific ones. This criterion is very important for teaching physics, because without diligence and understanding of the subject material the retention process drops sharply. Motivation in the educational process includes many components, and one of them is a cognitive interest [1, 3].

There are many ways to develop cognitive interest, which are described in the literature [2-4]; the most interesting, in our opinion, is the lesson performed in the form of games (lesson-game). Interdisciplinary allows students to show how such subjects from the school curriculum as physics and mathematics can be interconnected. Of particular interest in this integration for students is the fact that all tasks are presented not in the form of math or physics problems, but in the form of riddles that must be solved by students if they want to move on to the next task (problem).

The development of schoolchildren’s divergent thinking in the course of training is assumed, but hardly used. The physics curriculum is aimed at the development of convergent thinking, when students solve the problems prepared for them, and the results can be verified with the prepared answer. This is another difficulty in modern education [2, 7 9]. Children solve ready-made problems, look for ready-made answers in the Internet – as the result we have a vicious circle where the teacher is no longer a teacher, but simply a person who retells information, and the student does not learn, he/she only guesses the correct answer. It is very important to solve physics problems according to standard rules, to learn how to formulate a solution according to generally accepted requirements. However, in this case, the creative component is lost, however, it is necessary for children for their future life. As they grow older, they will increasingly have to face problems that require, as a rule, non-standard, non-standard solutions [5].

Underpinning the basic skills for forming/shaping engineering thinking at school, we help the student to decide on future professional activities at the earliest stage of education, at the time of the formation of the student's personality. A very important part of the training is not only theoretical study of engineering problems by the student, but also the ability to recreate models of a mental experiment in practice that is undoubtedly one of the most important development tasks of engineering thinking. The ability to create these or those projects in reality, rather than to leave them at the stage of abstract ideas, is undoubtedly a priority task of a modern engineer [6, 8].

According to the principle of openness, it is necessary to give students such problems that has no ready answer, no correct solution. To solve these problems, the student begins to use all the components of engineering thinking, in particular those that are not used in the usual mode of schooling.

2. Materials and methods

To increase students' motivation, as well as to form students' engineering thinking, we chose a lesson-game as the most vivid example of practice-oriented teaching.

3. Discussion

The proposed lesson fulfills the task - to build the model of the solar system. But this must be not a simple design and construction but a deep didactic analysis. At the beginning of the lesson students are offered only limited data that are necessary for the construction of the model - some diameters of the planets and some mass limits of these planets. The planets are arranged in a table in random order; the information about the distances to the Sun does not contain all figures. (Table 1).

Table 1.

Planet	Diameter (km)	Volume (m^3)	Mass(kg)	Density (kg/m3)	The distance to the Sun (km)
Sun	1391016				-
Mercury					
Earth	12756				
Mars					
	143884				
Saturn					
	51118				
Neptune		6,25*1013			
Pluton	2374				

Students are divided into teams consisting of 2 to 4 people. Each team is given a question card with riddles (Fig. 1), mixed in random order. Thus, the tasks of all teams are different, but the goal is the same, this provides the competitive component of the learning process, reinforces the desire to win. The fact that the team consists of several people, each of whom has his/her own solution to the riddle develops the ability to listen to each other, learns to recognize that the decision of a teammate may be more interesting and encourages to offer their own version.

The solution of encrypted problems is based on the material covered, in physics this is the concept of body density, the link of density with mass and volume. Everything about the plans of the solar system, the laws of gravity, the general properties of the terrestrial planets and giant planets, the nature of the bodies of the solar system. In mathematics, the solution is based on the knowledge of the basic properties of proportions. We will systematize the students' knowledge on the topic “Proportions. The fundamental properties of proportions”, increase the applied and practical focus on the topic study, strengthen the capacities to draw conclusions, develop skills of self-control and mutual control.

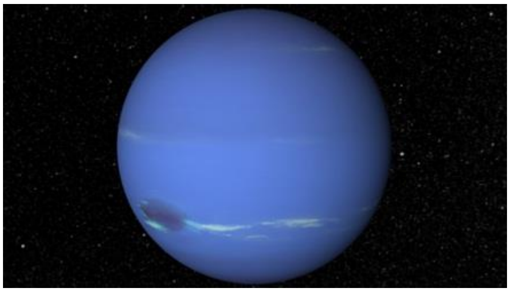
5.	**6.**
	
The Lord of the Seas, with 13 satellites, including Triton.	The most famous dwarf planet, which was considered a planet until 2006.

Fig. 1. Riddles with pictures

Every new puzzle is built on the fact that the previous one has been guessed, and so on, until the entire table will be filled. Then students need to build a model of the solar system. They use paper as a material for the model (20 sheets per team), empty plastic cups, and a rope (the same length for each team). Any spherical bodies as a building material of the solar system can not be issued, since this greatly simplifies the problem. The time allotted for the calculation is one academic hour. Building your model is another academic hour. The modeling lesson is held in free form, each team builds its own 2D model of the solar system. Evaluation of the finished model is carried out according to the following parameters - lead time, accuracy, ingenuity, creative component.

4. Results

The results of lesson will be the construction of the model of the solar system. As a result, we see the application of engineering thinking skills in life, as well as the transfer of the project-modeling algorithm from theory to practice. In addition, the lesson develops spatial orientation, allows building simulated objects more accurately in the future. An important factor in forming engineering thinking is a team work, since in the initial stages of learning the possibility of discussion, a scientific dispute between the participants is a more productive way of obtaining the final result.

5. Conclusion

Conducting cross-curricular games allows students to form the following qualities:

a) the ability to organize oneself;

b) to take into account the opinions of teammates;

c) to apply skills acquired not only during the study of one discipline, but during the whole learning process.

One of the most effective ways to form engineering thinking is a lesson-game. Motivation for learning through didactic games is a promising direction in teaching physics, which requires further development.

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